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POROSITY EVALUATION OF ADDITIVE MANUFACTURED PARTS USING NONDESTRUCTIVE TESTING

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ABSTRACT

The paper presents porosity evaluation of additive manufactured parts using ultrasonic nondestructive testing including scanning acoustic microscopy, ultrasonic velocity measurement, and ultrasonic attenuation coefficient measurement. Additive manufactured samples containing various levels of porosity were fabricated under various processing conditions. The scanning acoustic microscopy images clearly showed the porosity distribution and its quantitative amount in the samples. The ultrasonic velocity and ultrasonic attenuation coefficient results were related to the porosity results measured from the scanning acoustic microscopy. The increase in porosity caused the decrease in the material density, which resulted in the decrease of ultrasonic velocity and the increase of ultrasonic attenuation coefficient.

Keywords: additive manufacturing, porosity, ultrasonic nondestructive testing, scanning acoustic microscopy

1. INTRODUCTION

In recent years, additive manufacturing (AM) has been actively studied in various fields. Here, one of the current issues is to detect internal defects, such as porosity and lack of fusion, that can occur during the AM process for quality assurance [1, 2]. This study investigated the porosity evaluation of AM parts using ultrasonic nondestructive testing. Scanning acoustic microscopy (SAM) was used to evaluate the porosity distribution and its quantitative amount in AM parts. The ultrasonic velocity and ultrasonic attenuation coefficient were also measured and related to the porosity results measured from the SAM.

2. EXPERIMENTS

Seven titanium samples were fabricated by selective laser melting. To induce various levels of internal porosity, a scanning speed varied from 850 to 1270 mm/s at a fixed laser power of 275 W. The sample size was 20 mm x 20 mm x 0.28 mm.

SAM using a 75 MHz PZT transducer was used to evaluate the porosity distribution and quantitative amount. Also, the ultrasonic velocity and the ultrasonic attenuation coefficient were measured based on the pulse echo method using a 10 MHz PZT transducer.

Figure 1 shows the typical SAM images taken from the samples fabricated at different scanning speeds. In the image, the bright spot means the internal defect. It is clearly observed that the sample fabricated at a 1270 m/s scanning speed has a lot of internal porosity than the sample fabricated at 1020 m/s scanning speed. Based on the SAM images, the quantitative amount of the porosity was calculated using 2D image analysis software "ImageJ", and the results are shown in Fig. 2. The porosity increased when the scanning speed was deviated from the optimal value because the lack (or excessive) energy could not induce the optimal melting of titanium powders.

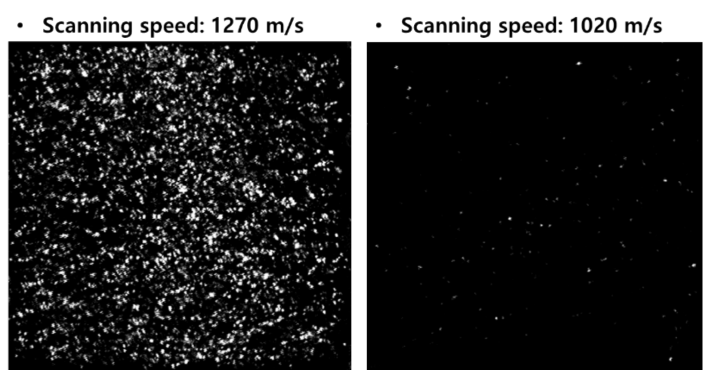

FIGURE 1: TYPICAL SAM IMAGES TAKEN FROM THE SAMPLES FABRICATED AT DIFFERENT SCANNING SPEEDS

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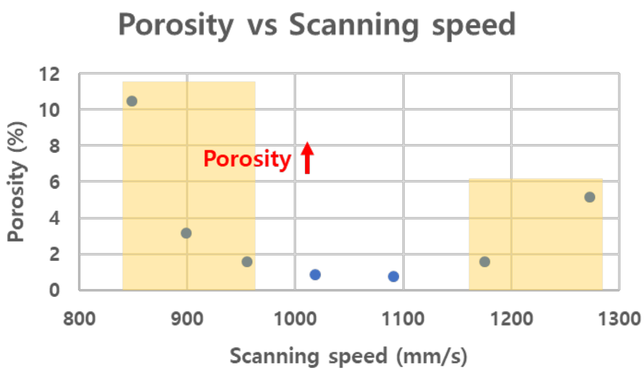

FIGURE 2: THE QUANTITATIVE AMOUNT OF POROSITY ACCORDING TO THE SCANNING SPEED

Figures 3 and 4 show the measured ultrasonic velocity and ultrasonic attenuation coefficient versus quantitative amount of the porosity. The measured ultrasonic velocity decreased with increasing the porosity due to the decrease in the material density. For the same reason, the measured ultrasonic attenuation coefficient increased with increasing the porosity.

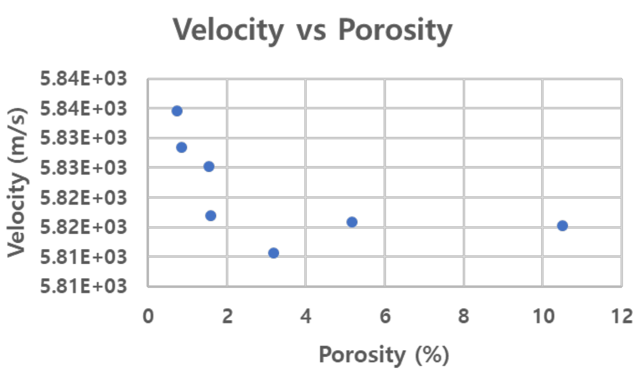

FIGURE 3: MEASURED ULTRASONIC VELOCITY VERSUS POROSITY

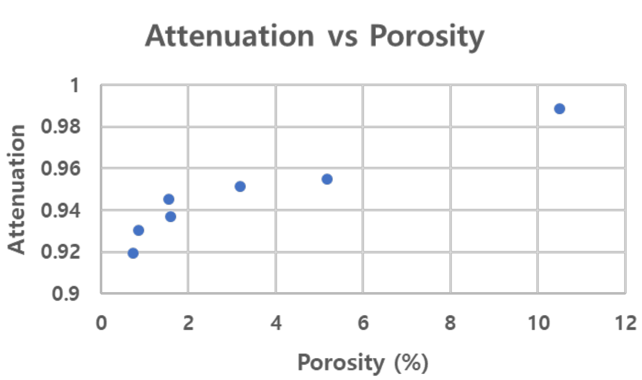

FIGURE 4: MEASURED ULTRASONIC ATTENUATION COEFFICIENT VERSUS POROSITY

3. CONCLUSION

The porosity evaluation of AM parts using ultrasonic nondestructive testing including SAM, ultrasonic velocity measurement, and ultrasonic attenuation coefficient measurement was investigated. AM samples containing various levels of porosity were fabricated under various scanning speeds at a fixed laser power condition. The experimental results showed that SAM is an effective method to evaluate the porosity distribution and its quantitative amount in AM samples. It was also observed that the ultrasonic velocity and ultrasonic attenuation coefficient are highly related to the porosity level. From these results, it can be identified that the ultrasonic nondestructive testing is effective for porosity evaluation of AM parts.

ACKNOWLEDGEMENTS

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